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PRESENT LINES OF ATTACK ON ANIMAL PARASITOLOGY[1]

IN treating the subject suggested by the secretary of this section, it is my desire to follow out his suggestion by discussing some of the general problems at present being attacked in the field of animal parasitology in order to point out if I can what measure of success is being achieved in each field and what appears to be immediately in sight for future consideration. Evidently within the limits of such an address only general statements can be made and details must be cited sparingly if at all. Animal parasitology has developed more in the last decade than in the entire previous period of recorded science, and the contrast in America is even more striking than in Europe.

Before taking up the general discussion, I wish to deal with a particular item that was included in the duty laid upon me. In common with many other speakers on this occasion which marks the seventy-fifth anniversary of the organization of the American Association for the Advancement of Science, I was asked to review briefly the work done on this topic of animal parasites, under the auspices of the association. I have elsewhere commented on the fact that when about 1845 the distinguished naturalist Dr. Joseph Leidy, founder of American parasitology, began to study and write on animal parasites, he entered upon virgin territory, for no work had been done previously on that subject in America, and for many years he worked alone. The start of his studies was roughly coincident with the founding of the association. Leidy's work was done in Philadelphia, and he does not appear as a contributor on this theme to the printed volumes of the association. In all the early years these volumes contain only four papers on parasitology, and but one of these was more than trivial, *viz.*, that by Weinland on "Human cestodes new to science"; this paper outlined his well-known book with the same title, published a little later in the year.

Between 1885 and 1890 a number of important studies on insect parasites and parasitism were presented at meetings of the association. Especial mention should be made here of the work by C. V. Riley, who was evidently a leader and inspirer of the group of workers. Beginning in 1892 came a series of papers on helminthology, slowly but steadily increas-

[1] Read before Section N, at the Cincinnati meeting on December 29, 1923.

ing in numbers, until to-day the joint program of the American Society of Zoologists and of the section on zoology in the association devotes one or more sessions to the consideration of papers on parasitology.

This relation of the association to the subject conforms reasonably clearly to the general attitude of the country. The early students of parasitology in Europe had no contemporaries here in the same subject. Leidy found the field unoccupied and worked in it alone for many years before activity was manifested first in entomology, later in helminthology and finally very recently in protozoology.

THE GENERAL SITUATION AT PRESENT

The years of the Great War were a period of tremendously rapid advance not only for workers in the field of animal parasitology who were given position, authority and material support that enabled them to attack vigorously the problems in this field, but also for the solution of those problems which under the conditions of warfare presented themselves in acute fashion and in concentrated form. Out of this has come a wealth of discovery exceeding that of any previous period even though it be given time limits manyfold greater. It is not necessary that I should review here in detail these discoveries or their practical application in measures for the protection of the combatants. It is interesting to note that in some cases the method of handling the problem in a practical way was developed beyond our knowledge of the causal organisms. Thus we do not yet know the character[2] of the organism causing typhus or trench fever, though we have had positive demonstration of their transmission by lice and have been able to work out measures of control which at least under conditions in time of peace will serve to limit the spread of the diseases if not actually to exterminate them. Of course this situation was not novel, for a parallel instance is to be found in yellow fever, where, thanks to the splendid work of a series of American investigators, and even at the sacrifice of life by some of the leaders, positive evidence was secured regarding the transmission of the disease out of which grew promptly the effective measures for its control. It was indeed many years after the magnificent work done by the commission, consisting of Drs. Reed, Carroll, Agramonte and Lazear, that Noguchi was finally able to determine the causal organism as a spirochete and to round out the life history.

But even when all such cases have been taken into account, it must be recognized clearly that the speed at which such investigations progressed was very greatly accelerated by the conditions of the war, and we find ourselves to-day in possession of increased information and new problems to a degree that could not have been predicted or probably realized under any other conditions. In examining this situation, however, one must recognize that the methods for utilizing the information gained regarding these parasites and for limiting their immediate attacks upon their hosts have outrun distinctly at numerous points the information concerning the structure, development and bionomics of the causal organisms, and also of their transmitting agents in those cases where such are found. The further effective progress of the clinical worker is thus being retarded and in some instances entirely stopped and additional information concerning the parasites must be worked out if the work is to continue to develop. This information is needed in the oldest as well as in the newest phases of the subject.

THE MORPHOLOGY OF ANIMAL PARASITES

The morphologist faces a wealth of problems which have not yet fully presented themselves, but which are rising out of the uncertainty of the situation with increasing distinctness. There is a time-honored list of human parasites, for example, to which it has been customary to assign forms that present themselves often without very careful examination into the character of the material in question. To the worker unfamiliar with the field many forms in a given group present a relatively uniform appearance and any human tapeworm, for instance, is likely to be labelled with the name of the common species *Taenia saginata*, provided only it has a head without hooks or if the general appearance of proglottids under the lens seems to correspond to a book figure of that species. It is worthy of note that at various times trained observers in different parts of the world have commented on certain peculiarities of specimens that they have secured, or have confessed their unwillingness to designate the material unequivocally as part of the common species. The latest of such instances comes from Japan where Isobe speaks frankly of his difficulty in reconciling the appearance of specimens of an unarmed human tapeworm with the classic description of the species *Taenia saginata*. Thus, even in connection with one of the oldest and, one might say, the best known of human parasites there exists a real doubt as to its range, and one with justice might adopt as a working hypothesis the view that very likely other closely related species are present in various parts of the world and have up to date been confused with the classic European form. Such a hypothesis does no violence to the teachings of the past in this field. For even the masters of helmin-

[2] Recent papers by Wolbach and others indicate that the solution of this problem is being approached.

hology have confused with each other species of the more or less similar form which on careful study were found to be clearly distinct.

I am well aware that many will regard such a study as suggested as of relatively little significance, and it is rather the tendency for those who deal with these organisms in a practical way to feel that accurate morphological determinations are of very subordinate value. I can not share such a view. It appears to me clear that our experiences indeed furnish the best of evidence that this attitude is untenable. It was not of secondary significance that Stiles by careful morphological study demonstrated the existence of a new hookworm which previously had certainly been encountered frequently, but which always had been confused before that with the type of hookworm first described. I am sure the magnificent progress which has been made in handling hookworm disease, as well as our comprehension of the problem, depends in a very evident way upon the demonstration that he furnished of the existence of the second species which has proved to be not only unlike in distribution as well as structure to the older form but also has manifested particular bionomic factors that are of significance in the attack upon the problem of eradicating the hookworm disease. Indeed, the discoveries in this direction have not reached the limit, even though splendid contributions have been made by a long series of energetic and effective students of the problem.

One of the ever-present problems in animal parasitology is the elimination of errors which have crept into earlier records by virtue of lack of precise determination of the forms involved. It is unnecessary to call attention in detail to the many cases in which workers in the field have been led astray by preliminary determinations that grouped together as identical forms that really were distinctly or sometimes conspicuously different in structure. By virtue of such errors many serious mistakes have been introduced into general discussions concerning the life history, distribution and significance of parasitic organisms. Recent thorough revision of the actual material utilized by earlier investigations and now in European collections has resulted in clearing up certain elements of confusion in earlier records. It is of course impossible to apply this method to testing all the records of earlier students, but its value has been so distinctively proved that it should be carried much further and all the collections available in the museums of the world be subjected to renewed and careful study at the hands of specialists on the various groups. One can not too strongly insist upon the need for the study of the original specimens or of material collected in the same territory and from identical hosts. Unfortunately, many revisions have been merely literary studies of the figures and descriptions of earlier authors and have in some instances certainly contributed further to the confusion existing. Textual analysis and critical sentence study is of little value in the determination of scientific data, and the imperfection of earlier observations and descriptions leads under such circumstances only to the repetition or amplification of error. The important fact is not what the earlier author said or what he thought he found but rather what the conditions actually are in material such as he studied. Only by attacking the problem from that standpoint is it possible to make contributions of permanent value or real advances upon the work of the original authors.

The work of Looss on the structure of parasitic worms and the fundamental revision he was able to make by following out this method is complete justification of the value of such procedure and stands in sharp contrast with the uncertain findings and confusing statements of some contemporaneous revisers who depend more largely, if not entirely, upon textual analysis of the records of earlier authors.

Life History Problems

Some 50 years ago parasitologists were actively interested in working out life cycles and through the efforts of Leuckart and others a series of classic examples of the development of individual parasites was added to our knowledge and have been incorporated as typical instances in lecture courses and textbooks ever since. Indeed, they had come to be so thoroughly established in the individual mind as the actual and perhaps necessary course of development that the scientific world did not react favorably to studies which seemed to modify these older conceptions. Undoubtedly, the first of these newer studies both in rank and time is the story of the development of the hookworm as worked out by the painstaking researches of Looss. It is worth noting that when that distinguished parasitologist presented his communication outlining the life history of the hookworm to the International Zoological Conference at Berne in 1904, I myself heard distinguished older workers in the field label the account as a fairy tale to be ranked with the stories of Baron Munchausen and the tales of the Arabian Nights! But Looss was right and the value of his results was so evident that recently many have been led to attack anew life history problems in other parts of the field. The most noteworthy contributions in this line have been made on the Nematodes among which migrations in the host tissues seem to be the rule rather than direct development as was formerly held. The technical difficulties in the way of following out such life histories have proved serious, so that progress has been slow and many

interesting species still await a successful attack upon the secrets of their wanderings. Especial mention should be made of the noteworthy contributions in this field by Fülleborn.

Problems of epidemiology are fundamentally dependent for their solution upon the correct determination of the life cycles of the parasites in question. It can not be too strongly insisted upon that the determination of such life cycles is only possible with the worker who has devoted adequate attention to the precise morphology of the adult parasite and its various larval stages. Much confusion has been introduced in various cases by faulty determinations. It is unquestionably true that the larval forms of many different species are strikingly alike and only a most precise consideration of their morphology will suffice to furnish diagnostic data adequate for their discrimination. Thus, in the intensive search after the life history of the Japanese lung fluke (Paragonimus) and of the Japanese liver fluke (Clonorchis), which was undertaken simultaneously by a considerable number of Japanese investigators, these workers were led more than once into serious error because though able and highly trained investigators in their fields, they were not familiar with the minute structure of the larval forms being studied. Other species which were concomitantly present in the larval hosts were confused with the proper stages, and conclusions were drawn from experimental work that were seriously misleading. A splendid example of the opposite condition is furnished in the work of Leiper on the life history of the blood fluke (Schistosoma). That investigator, trained by Looss who must certainly be recognized as the master of the most accurate modern morphological methods, was able to find a solution for developmental problems in this species which had been vainly attacked by numerous able predecessors. The exceedingly precise studies of Faust, Cort and others on the microscopic structure of the cerceriae have furnished a basis for accurate discrimination between stages of the three species parasitic in man, and the value of the results stands in sharp contrast with the confusion introduced into the field by some industrious and enthusiastic workers who have been unfortunately without that technical knowledge of the group necessary to make their work of permanent value.

Much has been done through the experimental infection of hosts to secure larval forms in known stages and to determine the period essential for development under fixed conditions. These data are of the utmost importance in preventive medicine, and it is almost trite to emphasize the fact that the treatment of parasitic diseases must always be primarily and often in its entirety a problem of prevention rather than of repairing the difficulty after the malady has made its appearance.

No better illustration of this feature could be given than that furnished by *Ascaris lumbricoides*. The dictum of earlier investigators that this species developed directly to maturity in the intestine after ingestion of the infective stage had been accepted without question, notwithstanding a lack of knowledge of what actually happened. When, however, the investigations of Stewart, Ransom and his coworkers, Fülleborn, and others established the facts in the life cycle of Ascaris, then an entirely new field was opened up. The migration through the tissues and the attacks upon the lungs were early seen to be directly connected with conditions in the host previously unexplained and not regarded as in any relation to the parasite. Its serious import to the host at once became evident and one could for the first time get a time picture of the significance of an organism previously considered of minor clinical and practical importance.

NEW FIELDS OF STUDY

Among the points of attack which seem to afford largest opportunity for valuable work at the present time, one may undoubtedly list prominently the field of microscopic organisms. We are only just beginning to know the significance of recent studies on protozoa which have already yielded extensive information concerning certain known types and which have resulted in the discovery of an immense number of hitherto unknown forms. Unfortunately, up to the present date our knowledge of most species has remained extremely fragmentary. The results of intensive studies on the intestinal amoeba have gone far beyond our expectations and have revealed a wealth of detail concerning the different types involved in the causation of disease, important data on their life histories and most significant features in their biological peculiarities. While one is forced to recognize the progress that has been made along these lines, it is still impossible to lose sight of the large gaps in our knowledge even regarding this and other "better known" organisms among the protozoa. The work already done is leading in directions entirely unsuspected at the start, and if only a part of the remarkable discoveries of Koford and others stand the test of repeated investigation the results will form one of the most brilliant chapters in the history of this field. One needs only to mention Trypanosomes and Trypanosomiasis to suggest at once to the mind an immense literature which has resulted from the studies of recent years and out of which has grown not only valuable results for the specific problems attacked but also influences that are far-reaching in the field of chemo-therapy.

Of all such organisms only occasional forms parasitic among lower animals have been subjected to extended investigation, although many of them are of

marked economic importance and great biological interest. Even among the parasites of man there are many protozoa which have been brought to our attention by isolated observations that will doubtless repay richly intensive study. One can not too strongly commend the type of attack being made upon such problems by Hegner and his associates at Johns Hopkins University. A thorough intensive investigation of the structure, life history and bionomics of a few forms will lay solid foundations for future work and render the conquest of the field more rapid and more certain than would be possible under methods that resulted in a more extensive examination of a larger number of species. It is also fortunate that an intensive attack has been organized against parasites of lower animals where continued study, experimental work and control of conditions essential for a thorough testing of the results and interpretation of them is possible; and more rapid progress is assured than if the beginning had been made only on the parasites of man. Indeed, in reviewing the field, it is noteworthy to see how many instances present themselves in which the investigation of human parasitic diseases has been held up by lack of an adequate basis in general knowledge concerning the parasitism of such forms.

Signs are not lacking to indicate the growing significance of a group of spirochetes to which recent investigators have assigned the causal organism found in connection with important diseases, the etiology of which has long waited for the demonstration of the causal organism. A study of this group has hardly been started as yet, although in Noguchi's demonstration of *Leptospira icteroides* as the causal organism of yellow fever marked progress has been made towards the determination of such forms and the methods for their study as well as for testing them in their relation to disease. Here it is certainly of the utmost importance that a thorough investigation be made of the problem of their nature and relationships and the determination of their proper assignment to plants or to animal organisms will yield biological evidence of the relationship of these two groups that will be of far-reaching significance in general biological studies.

Of marked importance are recent studies on the flagellates of plants and their relations to insect flagellate parasites. In the opening of this new field of work especial mention should be made of Franchini's investigations. Nothing could illustrate better than these studies the intimate and far-reaching relations to parasitism. Indeed, although hardly begun, they have already thrown some light on the problem of the origin of parasitic protozoa long known from the blood of vertebrates. It is not too much to hope that along this line may be reached the solution of problems of human disease hitherto entirely unexplained. Studies such as that contained in the paper just presented[2] by Strong show unmistakable relations between flagellates parasitic in plant and animal hosts that involve also the human species.

Within very recent times there has been published by J. Jackson Clarke, of London, investigations concerning a whole series of little known and less understood micro-organisms which he is inclined to consider closely related to some unusual groups of plants known only to a few technical workers in that field and not heretofore considered of general significance in human parasitology. While the results of this investigator have not as yet met with confirmation they open up a territory in which knowledge is scanty and interpretation exceedingly difficult. The investigation of such problems as this will demand the attention of specialists highly trained in the particular field of botanical research and an ultimate decision concerning the biological character of these organisms can not be reached by the investigator, however well trained in other lines, who is unfamiliar with the types to which it is claimed they are to be attached.

NEED OF COOPERATIVE RESEARCH

The application of results already obtained concerning the structure, life history and bionomics of parasitic worms to the prevention and treatment of disease requires the attention of specialists in the field of medicine if adequate results are to be achieved. Ultimately, then, the problems which are developed and carried to a more or less successful solution by parasitologists require for their fullest utilization cooperative work from the specialists in the medical field. It is just here that the work of this section may be expected to yield valuable results. Neither class of investigators alone can hope to achieve adequate success from a study of the problems that present themselves. The cooperation that in the past has been manifested in partial fashion or at individual points must be developed to include the entire subject. It is certainly desirable that workers of both types should find opportunity to carry on further investigations simultaneously and in close touch with each other. The splendid results that have grown out of such cooperative action in the few individual cases in which this method has been followed in the past promise even richer success when the method shall have become more general. While individual effort will still yield valuable results the most far-reaching success will fall to those who are able to organize and work out in a cooperative way an intensive study of some of the great problems concerning individual parasites that present them-

[2] "Relationship of certain parasitic infections of plants to animals," by Richard P. Strong.

selves. One needs only to look over the work done recently in the study of hookworm disease by the group organized at Johns Hopkins under the leadership of Cort, to recognize the full justification of this contention. May we not hope that in the immediate future many such undertakings may be similarly organized and be able to secure equally strong support Under such conditions one may safely prophecy rapid progress in the solution of the problems which present themselves in this field.

HENRY B. WARD

UNIVERSITY OF ILLINOIS

A FAULT MAP OF CALIFORNIA

A MAP which shows the the distribution of earthquake risk in California has been published by the Seismological Society of America and can be obtained from the Secretary, Dr. S. D. Townley, of Stanford University, California. The base of the map was prepared by the U. S. Geological Survey in cooperation with the California State Department of Irrigation and is both accurate and on a scale to show details. It shows the mountains and valleys by relief shading, drawn by John A. Renshawe of the survey, and carries the net of township surveys and Spanish landgrant boundaries, so that any property in the state can be located. It also exhibits the submarine contours from the shore out to the depth of 2,000 fathoms as determined with unusual detail and accuracy by the U. S. Navy by means of the Sonic depth-finder in 1922. Upon this base the known faults, which traverse the Coast Ranges from Mexico to Humboldt County and encircle the Sierra Nevada, have been mapped by the undersigned.

The Fault Map of California, although neither complete nor perfect, presents a large array of facts, which may be useful in various scientific and practical ways. The research student who is occupied with problems in structural geology relating to faulting and folding will find in it examples of those structures actually in course of development. The isostatic equilibrium of the Sierra Nevada and of the great coastal scarp may be examined in the light of more complete evidence than we have previously had. The displacements of triangulation stations, recently determined by the Coast and Geodetic Survey to be of significant magnitude, may be accurately indicated on it in relation to the faults which limit the moving masses. The teacher of geology or geography who desires to illustrate some point connected with the relief of the earth's surface will find the facts clearly displayed in the beautifully shaded base map produced by Renshawe. The investigator of submarine relief is given an unusual opportunity to study the forms of the ocean bottom in the detailed contours drawn on the soundings secured by the navy with the cooperation of the Hydrographic Office. Here are forms attributable to faulting, to aggradation by terrigenous sediments, to submarine erosion, or to subaerial erosion, now submerged.

On the practical side the map serves to define the areas of earthquake risk in a way which may enable the dwellers in any given valley, or township section indeed, to determine the proximity or distance of a probably active fault. Engineers should no longer build in ignorance of the existence of dangerous rifts. Insurance men should no longer lay a blanket premium on buildings in California where the risk is quite as unequal in different parts as it is between Tokyo and New York. The conditions of building and the building regulations of communities should take account of the facts that are brought out in the Fault Map.

While we have sound reason for the opinion that these things are so, we recognize that the Fault Map as it now stands is a first attempt to present the facts on this scale and, like other first attempts, can be much better done another time. It is to be hoped that one of its principal services will be to stimulate the study of faults and their relations to earthquakes.

A noteworthy feature of the Fault Map is that it expresses a distinction between active faults and dead faults. This distinction appears to have been recognized first by Branner, Gilbert and Lawson, after the California earthquake of 1906, and the term "rift line" was used in the report of the Earthquake Commission to describe one type of outcrop of an active fault. The great San Andreas fault exhibits this type. Its relation to the shock of 1906 was evident throughout the entire distance, 190 miles, along which the disturbances of the ground were traced, and it exhibited peculiar topographic features, both in its relation to mountains and valleys and also in the peculiar occurrence of various minor features in longitudinal arrangement, by which it or other faults of like recent activity could be followed. The definition of an active fault is thus that it is a fault on which there has been a movement within a period so recent that sequential displacements may reasonably be expected to occur along it. It is obvious that the definition can not be applied with exactitude when it comes to distinguishing an active from a dead fault. There are active faults which are known to have suffered displacements within our experience, and there are dead faults which can be proved not to have suffered any displacement since the Pliocene; but between the unquestionable examples there is a wide range within which conscientious observers may differ as to the classification. It is also true that men are cautious in earthquake countries in ascribing dangerous activity to any feature that might give rise to an

earthquake. They would rather err on the conservative side and it follows that the average geologist, who as a rule has had but little training in recognizing the evidences of activity, usually describes faults simply as faults, without distinction as to their activity.

These conditions led to a difference of interpretation of the term active as it is used in separate sections of the Fault Map. Mr. Wood, who gathered from many generous contributors much of the fault data shown on the southeast, and the southern portion of the southwest, sheets of the map, subsequently examined many of these faults in the southeast region, and some elsewhere, and found it desirable to recognize a considerable number of grades of knowledge corresponding as nearly as might be to the degrees of certainty with which the faults, and their symptoms of activity, were determined. His manuscript map shows the following distinctions: active fault well located; active fault uncertainly located; fault probably active; line probably active fault (?); fault well located; fault uncertainly located; line probably active; line including all from probably fault to very doubtful; line including all from probably fault to very doubtful and uncertainly delineated. Mr. Willis, who is responsible for the mapping in the districts north of San Luis Obispo, with the assistance of Mr. Robin Willis, made a reconnaissance survey of the area between San Luis Obispo and Santa Rosa, and extended the application of the term active to faults which he recognized as such on physiographic evidence as well as on indications more commonly employed, whenever in his judgment the facts justified that classification. He thus classified as active many faults which he would not have identified as such without personal examination.

The task of transferring the manuscript data to the copy for the printer fell to Mr. Willis and involved the adjustment of the differences of interpretation in so far as it might be possible to bring them into accord. It was not possible, however, to reach that desirable unity of statement which might have been attained if all the evidence could have been reviewed by a single observer. It was necessary also to reduce the number of distinctions to that which could be shown by a moderate number of printings on the map. The adjustments were made by Mr. Willis on the eve of his departure for Chile and an explanatory note was inserted by him in the legend of the map just before sailing, without opportunity of consultation with Mr. Wood. The note falls somewhat short of a complete statement of the facts. On the southeast sheet it reads that the faults thereon shown as active "have been active during historic time" and it should further explain that the classification as active also includes such as "exhibit specific surface indications of recent activity, such as fresh scarps and trace phenomena." Furthermore, a considerable number of the faults shown on the southeast sheet, and also on the southwest sheet, that are marked dead, would better be indicated as, "probably active, but without definite indication of recent disturbance." Were these changes made in the map itself the number of active faults shown in the southern half of the map would more nearly approximate that of the active faults delineated by Mr. Willis in the northern half.

In making this compilation we have been placed under obligations to many individuals, corporations and institutions. Some of them have wished not to be named and the list of others who have contributed to the advancement of our knowledge of California is too long to be given here. It is appropriate to state, however, that the work was done in cooperation with the Advisory Committee on Seismology of the Carnegie Institution of Washington, with the U. S. Geological Survey, represented especially by Messrs. Noble and Kew, with the U. S. Hydrographic Office, with the Navy Department, with the University of California and with Stanford University. While the Seismological Society of America is directly responsible for the publication, it could not have accomplished it without the cordial cooperation given by these organizations.

BAILEY WILLIS,
H. O. WOOD

DETERMINATION OF THE CURVATURE INVARIANT OF SPACETIME

ON January 30, 1924, and on the two following days a remarkable series of lectures was delivered by Dr. Silberstein to the Physical Society of McGill University, Montreal. Not only did Dr. Silberstein present to his audience one of the vastest problems with which the human mind can grapple, but he gave for the first time in public an exposition of his own investigations of the intrinsic properties of spacetime as the frame of the universe.

The preliminary lectures dealt with the geometries of space and spacetime; the early attempts to formulate mathematical equations which would hold true not only for terrestrial measurements but also for planetary measurements; the discrepancies which invariably occurred between theory and observation in the latter class of measurements; the great conception of Einstein whereby the universe was to be treated mathematically as a four-dimensional "spacetime" continuum, and his later inspiration, whereby he conceived spacetime as finite according to the principles of elliptical geometry; the modification of the Einstein spacetime equation by de Sitter, whose beautiful theory has overcome the outstanding difficulty of

Einstein cosmology and has prophesied not only measurable but conspicuous deviations from classical theory for measurements dealing with distances as great as those of the remote stars and nebulae.

The third lecture dealt with Dr. Silberstein's own investigations based upon the spacetime theory of de Sitter. Attention was confined to a discussion of Radial Velocity. This velocity in the line of sight is measured by the Doppler effect, that is to say, by the displacement of a spectral line in the spectral photograph of a star relative to the position of that line in the spectrum of a similar source of light on the earth.

Both de Sitter and Weyl showed theoretically that the greater the distance of the star from the observer, the greater would be the shift of the spectral line; but their theories only allowed for a shift towards the red end of the spectrum. In the case of de Sitter, this was because he limited himself to the perfectly artificial assumption of the star fixed relative to the observer; and in the case of Weyl because he introduced the quite gratuitous assumption that the world lines of all the stars belong to a unique pencil of geodesics diverging into the future. Observation, however, shows that not all the stars are receding, a considerable proportion having motions towards the solar system, while of the 42 spiral nebulae whose velocities have been measured four are approaching and likewise a large proportion of the globular clusters. Thus the spectral shift equations of de Sitter and Weyl are untenable; first, because they are theoretically unsatisfactory, being based on a gratuitous or a narrow assumption and, secondly, because they are flatly contradicted by many of the most remote celestial objects.

Dr. Silberstein has taken up the problem without introducing any limitation whatever into de Sitter's spacetime theory, thus entirely abandoning the prejudice of the universal scattering of matter. He treats the observing station and the star as two free particles and integrates the equations in their full generality. This leads him to a formula for the complete spectral displacement, a general Doppler formula containing two terms due to (1) an individual characteristic of the star considered, namely, the radial velocity which it would have at its closest approach to the observer, whether that position occurred in the past, or would occur in the future, and (2) the ratio of the distance of the star from the observer to the radius of curvature of spacetime. Although these two factors are inseparably amalgamated, yet the first dominates the result for stars near the sun, while the second far outweighs the first for stars near the boundary of our galaxy or for the spiral nebulae which are themselves probably small galaxies lying far out beyond the confines of our galaxy.

Dr. Silberstein has collected all the numerical results which are available—namely, Shapley's observational data—with regard to the Doppler displacements and distances of globular clusters and the Magellanic Clouds, and inserting these values in the equation embodying the relations above described he solves for the only unknown—the radius of curvature of spacetime. The results are so consistent from the clusters, whether approaching or receding, and from the two Magellanic Clouds, that it is impossible not to attach a tremendous importance to this achievement of Dr. Silberstein's. Thus, an intrinsic feature of the universe, the radius of curvature of four-dimensional spacetime, having a clear mathematical significance but utterly impossible of visualization in the ordinary sense of three-dimensional realization, has been evaluated numerically with a precision and weight never before approached. The consistency of the nine values obtained gives rise to a law which can be enunciated in terms of physical observable things, thus: the product of the Doppler displacement and the parallax is a constant, and this constant has the simple physical meaning of the smallest possible parallax in such a spacetime, namely, the ratio of the earth's distance from the sun to the radius of curvature of spacetime.

The figures given by Dr. Silberstein as the measure of this radius of curvature are as follows: The mean of determinations from seven globular clusters is 6.0 multiplied by 10 to the power twelve in astronomical units, and the mean value of these seven clusters, together with the Greater and Lesser Magellanic Clouds, is 6.07 multiplied by 10 to the power of twelve.

Gigantic though this figure may be, it yet implies a finite volume of the elliptical space as a section of spacetime, and the thought of "a closed elliptic cage" would be intolerable to the undaunted imagination of Dr. Silberstein, were it not relieved by this inherent property of the spacetime, strangely stimulating to what Clifford termed "cosmic emotion," that a light signal from a star near the observer's polar (the polar is a sphere around the observer of the greatest possible radius in that space) would take an almost infinite time to reach the observer, while from a star actually on the polar the signal would come—never.

A. VIBERT DOUGLAS

McGILL UNIVERSITY

SCIENTIFIC EVENTS

THE MASSES AND LUMINOSITIES OF THE STARS[1]

AN important paper on this subject was read by Professor A. S. Eddington at the meeting of the

[1] From *Nature*.

Royal Astronomical Society on March 14. He provisionally assumed that absolute magnitude could be expressed as a function of the mass plus a constant; also that absorption in the star's interior varies as density/(temperature)$^{\frac{7}{2}}$. A curve was drawn in which Capella, the mass of which is accurately known, was taken as the standard star. The masses of the highly luminous stars were taken from Professor Shapley's results for the Cepheids and Professor Plaskett's recently published results for Algol-variables in which both spectra can be photographed. The other end of the curve was filled in from the masses of the binary stars of large parallax. Professor Eddington noted that he had not expected that the results from drawf stars would fit on the curve derived from giant stars, but to his surprise they did so. He concludes that the principle, enunciated when the giant-and-dwarf theory was started, that the dwarf stars do not obey the laws of a perfect gas, is unsound; that, in fact, these laws are obeyed even for densities much greater than that of the sun. He thought that this fact might be explained by the atoms in the interior of the stars being ionized and stripped of their outer electrons. Their bulk is thereby greatly reduced, and there is room for them to move freely, even when the density is considerable. The interior of the dwarf stars continues to get hotter and hotter, but the surface cools by radiation.

Professor Eddington suggested that the small mass of the dwarfs might be due, as he had indicated some years ago, to the annihilation of matter within the star, colliding atoms destroying each other and liberating the large amount of energy locked up in them. The mass of a star would thus be less in its old age.

The results of the paper would necessitate considerable alteration in the manner of stating the giant-and-dwarf theory. Professor Eddington did not anticipate opposition from the authors of that theory (Professors Russell and Hertzsprung), as he gathered from recent communications that they were reaching conclusions similar to his own.

MORTALITY FROM DIABETES

ACCORDING to the Metropolitan Life Insurance Company one of the most encouraging items in the 1923 mortality statistics of the industrial policyholders is the drop in the diabetes death rate. The decline, it is true, was only 6.4 per cent., the death rate in 1923 being 16.1 per 100,000 as compared with 17.2 for 1922. But slight as is the drop it may have great significance; for it follows a period of three years during which time deaths from diabetes had been increasing continuously and at a considerable rate. Between 1919 and 1922 the rate rose 28 per cent. These figures for the company's industrial department relate to the great group of American and Canadian wage-earners; but there are also available from the ordinary and intermediate departments of the company (which include policyholders of a somewhat higher economic status) figures which show considerable declines in 1923 in deaths from this disease. Among the ordinary policyholders 7.8 death claims were paid in 1923 per 100,000 policies in force as compared with 10.5 claims in 1922; and in the intermediate department, 9.6 claims were paid as compared with 10.2 in 1922.

The interesting fact is, of course, that the lower diabetes death rate last year was contemporaneous with the beginning of the more or less general use of insulin to check the devastating effects of this disease. It is too early, as yet, to say finally that the sudden check in the rising mortality from diabetes is to be credited to the use of this apparently successful treatment. Before this can be done we must have figures showing declines for a series of years, and a greater rate of decrease must be shown. If the rate drops again in 1924 it will be safe to assume that there is *some* well defined cause for the reversal of the trend which was observed between 1919 and 1922. And, as there appears to be no *other* outstanding reason for the check in diabetes mortality last year, it is extremely probable, to say the least, that the increasingly successful and widespread use of insulin was the chief factor in lowering the death rate from this disease.

The mortality figure for diabetes, so far in 1924, is more than encouraging. The January death rate for the industrial policyholders was 17.2 per 100,000 as compared with 20.3 for January, 1923. Obviously, we can not guage the outcome for 1924 by what has transpired in a single month; but the change is in the right direction. If this rate of decline persists throughout the year the fall in the death rate will be more pronounced than that recorded in 1923.

OIL AND HELIUM RESERVES

A SPECIAL commission has been appointed by President Coolidge to study the problem of conserving fuel oil for the navy and providing facilities for storing fuel. The commission consists of Dr. George Otis Smith, director of the Geological Survey; Rear Admiral Hilary P. Jones, president of the General Board and commander-in-chief of the United States Fleet, and R. D. Bush, of the Bureau of Mineralogy of the State of California.

In a statement issued at the White House, Mr. Coolidge said that the commission will make a general study of the problem, but specifically it will review the situation in each one of the navy's reserves and seek to ascertain whether it will be possible to create larger or better protected reserves than those existing. The statement says:

The purpose for which the naval oil lands were set aside was to provide reserves for the future. In order to do this in the best manner the oil should be, wherever possible, retained in the ground. Where this is not possible, however, it should be retained in tankage above ground.

This oil is an important part of the national insurance. At the present rate of production there is estimated to be but twenty years' of oil supply within the limits of the United States. When this is exhausted we will be dependent upon foreign sources for our supply. In time of war such supply will certainly be jeopardized and possibly cut off. Unless the navy has conserved in this country sufficient oil wherewith to fight a war, our national security is seriously endangered.

The general board of the navy, which has made a careful study of the problem of national defense, has recommended a presidential commission to give more careful study of the fuel question. In view of present conditions I have decided to appoint this commission now. This commission will have the same access to data and information contained with the governmental departments as was granted to the United States Coal Commission (H. R. 12,377) Sixty-seventh Congress. The commission will have as its mission the general study of this problem, but specifically it will review the situation in each one of the navy's reserves and endeavor to ascertain whether it will be possible, by assignment of additional public lands, transfers, trades, purchases or otherwise, to create larger or better protected reserves than those existing at present. This not only pertains to the United States proper, but, in addition, to such oil lands as might exist in Alaska.

It is also announced that President Coolidge, by executive order, has created in Mery County, Utah, the first helium reserve in the United States. It is designated as helium reserve No. 1 and consists of 7,100 acres of land in which the greater part of the mineral title is vested in the United States. The reserve is withdrawn from all forms of settlement, location, sale or entry.

Several prospecting permits on the area were issued three years ago and an oil company drilled to a depth of between 3,000 and 4,000 feet. No oil was found, but a helium bearing gas was encountered, which, under the terms of the general leasing law, is reserved to the United States. The extent and value of the deposits of helium are not definitely known, and the lands are still subject to various prospecting permits, but to conserve the helium for government needs, Secretary Work recommended to the President that a reserve be established.

BLACKWATER FEVER IN RHODESIA

ACCORDING to the *British Medical Journal* letters from Dr. J. Gordon Thomson, director of protozoology, London School of Tropical Medicine, who is at present in Rhodesia investigating blackwater fever, report that he has examined for spirochaetes the blood of six patients suffering from this disease. He adopted the method of triple centrifugalization of the blood used by Blanchard and Lefrou (1922), but so far has been unable to confirm their results or to demonstrate spirochaetes of any description. Examination of specimens with dark ground illumination, however, showed numerous fine threads or filaments, varying in length and thickness and possibly derived from the blood platelets, which simulated spirochaetes very closely indeed. Dr. Thomson has also attempted to make cultures—chiefly on Noguchi's medium—of any spirochaete which might be present, but his results have been negative. Inoculation of guinea-pigs has also failed to produce evidence of the existence of a spirochaete. Again, he makes mention of the fact that relapsing fever is fairly common among the native population, and that acute infective jaundice undoubtedly occurs, so it is quite possible that either of these diseases might be superimposed on an attack of malaria or blackwater fever. So far as he has gone Dr. Thomson is inclined to the view that blackwater fever is a manifestation of chronic malaria, and is due to some obscure haemolytic phenomenon caused by repeated attacks of malignant tertian malaria. In the parts of Rhodesia where malaria does not exist there is no blackwater fever, and, conversely, in the areas where malaria is prevalent blackwater fever is common.

BOTANICAL EXPEDITION TO SOUTH AMERICA

PROFESSOR G. S. BRYAN, of the department of botany of the University of Wisconsin, and Francis Macbride, of the Field Museum of Chicago, have returned from an expedition to South America made under the auspices of the Field Museum, bringing with them 6,000 specimens. Professor Bryan collected algae, fungi, lichens, liverwort, mosses, ferns and their allies, and Mr. Macbride collected specimens of flowering plants. Half of Professor Bryan's collection has been given to the Field Museum, and half of it will be placed in the botanical museum of the University of Wisconsin. The expedition, which sailed from New York last February, went *via* the Panama Canal, down the west coast of South America to Callao. From Callao, Professor Bryan and Mr. Macbride went to Lima, then by train over the western mountains to Cerro de Pasco, which is 14,200 feet above sea level. With a pack train they went over the mountains, 75 miles further into the interior, and established a base camp. They made three separate trips from there into the interior, near the headwaters of the Amazon River, which is practically a wilderness with only a few small native settlements. These

trips took about five months. A number of specimens were collected under great difficulty. The safe preservation and packing of the samples was a serious problem.

SCIENTIFIC NOTES AND NEWS

WE regret to record the death at the age of eighty-two years of Dr. Thomas Corwin Mendenhall, the distinguished physicist, formerly professor in the Imperial University of Japan and in the Ohio State University, superintendent of the U. S. Coast and Geodetic Survey and president of the Rose Polytechnic Institute and the Worcester Polytechnic Institute. Dr. Mendenhall was president of the American Association for the Advancement of Science in 1889.

THE Victoria Medal of the Royal Geographical Society of Great Britain has been awarded to Dr. John F. Hayford, head of the college of engineering of Northwestern University, for notable achievement in establishing the theory of isostasy.

DR. WILLIAM HALLOCK PARK, for thirty years director of the Bureau of Laboratories of the Health Department of New York City, has been elected a foreign member of the Paris Academy of Medicine.

MEMBERS of the Stanford chapter of Sigma Xi were hosts at a dinner on March 14, held in recognition of the fact that Stanford University has had five members of its faculty presidents of national scientific societies in one year. Guests of honor at the dinner and the societies concerned were the following: Dr. Ray Lyman Wilbur, American Medical Association and Association of American Medical Colleges; Dr. Edward Curtis Franklin, American Chemical Society; Professor Harris Joseph Ryan, American Institute of Electrical Engineers; Dr. Lewis Madison Terman, American Psychological Association, and Dr. Bailey Willis, Seismological Society of America. Dr. David Starr Jordan, chancellor emeritus of the university, presided as toastmaster at the dinner. More than 200 were present.

AT the annual meeting of the Geological Society of London on February 15, Dr. J. W. Evans was elected president. The vice-presidents elected are Dr. C. W. Andrews, Dr. J. S. Flett, Professor A. C. Seward and Professor W. W. Watts.

PROFESSOR W. C. M'INTOSH has been elected president and Sir David Prain a vice-president of the Ray Society, London.

IN recognition of his services to the organization, the New England Association of Chemistry Teachers has presented Dr. Lyman C. Newall, head of the department of chemistry at the Boston University College of Liberal Arts, with a copy of resolutions just adopted at its twenty-fifth anniversary meeting held in Malden. The resolutions acknowledge the work which Dr. Newell has done for the society and express the thanks of the organization.

DR. REGINALD DUDFIELD has been elected president of the Harveian Society, London.

AT the annual meeting of the British National Union of Scientific Workers, Professor G. H. Hardy, Oxford, was elected president, and Dr. J. W. Evans, president of the research council of the union.

DR. CLAYTON H. SHARP, technical director of the Electrical Testing Laboratories, New York, has been elected president of the United States National Committee of the International Electrotechnical Commission at the committee meeting held on March 12, succeeding Dr. C. O. Mailloux, resigned.

DU PU BARRETT, of the Forest School of the Georgia College of Agriculture, has been appointed state extension forester, in charge of logging and utilization.

EIGHT sub-committees of the research committee of the American Institute of Electrical Engineers are at work on different problems. These committees, with their chairmen, are designated thus: (1) Reviews and compendia of work already done, J. B. Whitehead; (2) nature of dielectric absorption, J. B. Whitehead; (3) phase difference in dielectrics, Delafield Du Bois; (4) electric strength, William A. Del Mar; (5) dielectric constant, T. S. Taylor; (6) resistivity, H. L. Curtis; (7) flashover voltage, F. W. Peek, Jr.; (8) theories, Vladimir Karapetoff.

PROFESSOR GEORGE KLINGENBERG, head of the Technical High School in Berlin and director of the General Electric Company in Germany, arrived in New York on March 23 to make a study of American power transmission methods.

DR. CHARLES SCHUCHERT, of Yale University, who has been spending some time at Tucson, Arizona, where he has been lecturing on historical geology at the University of Arizona, has started a leisurely return journey to New Haven. Dr. Schuchert plans to return to the University of Arizona next winter and deliver a series of special lectrues on stratigraphic paleontology.

THE Sigma Xi club, of Southern California, held a special meeting at the City Club, Los Angeles, on March 17, in honor of Professor and Mrs. J. H. Comstock, of Cornell University, who were visiting in Southern California. Dinner was served at six-thirty, after which the members enjoyed an informal talk on "Some notes on the early history of entomology in this country," by Professor Comstock, and on "The

responsibility of the scientist to the coming generation," by Mrs. Comstock.

AT the meeting of the Philosophical Society of Washington on April 5, the Reverend Dr. Francis A. Tondorf, of Georgetown University, will speak on "The seismogram and its interpretation."

DR. C. G. ABBOT, of the Smithsonian Institution, Washington, delivered an address on March 22 before the Royal Canadian Institute on "The sun and its influence on human affairs."

SIR J. J. THOMSON has been appointed to deliver the university lecture in science for 1924 by the University of Aberdeen.

DR. F. W. ASTON will deliver the annual lecture of the Institute of Metals on June 4, his subject being "Atoms and isotopes."

PROFESSOR C. V. L. CHARLIER, professor of astronomy in the University of Lund, Sweden, lectured at Dartmouth College on March 24 and 25 on "Statistics and mechanics" and "Statistics and physics and astronomy."

AT the memorial services in honor of Dr. Emmett Holt, at the New York Academy of Medicine, on March 12, the Rev. Dr. William H. P. Faunce, president of Brown University, and Dr. Simon Flexner spoke on "Dr. Holt, the man"; Dr. John Howland on "Dr. Holt, the physician"; Dr. Henry L. K. Shaw on "Dr. Holt, a pioneer in social medicine," and Dr. George David Stewart on "Dr. Holt, trustee and fellow of the Academy of Medicine." Dr. Royal Storrs Haynes was in charge of the meeting. Students at the College of Physicians and Surgeons have contributed toward a memorial tablet to be placed in the New York Academy of Medicine.

ON March 14, the Baconian Club of the State University of Iowa held a meeting at which the scientific contributions of Jacques Loeb were reviewed as follows: Zoology, Gilbert L. Houser; chemistry, Donald H. Cameron; psychology, John J. B. Morgan; botany, Clifford H. Farr.

DR. ALEXANDER MACGILLIVRAY, for the past thirteen years professor of systematic entomology in the University of Illinois, an authority on insect morphology, on the classification of the Coccidae and the Tenthredinoidea and on the immature stages of insects, died suddenly at his home in Urbana, Illinois, on the morning of March 24, aged fifty-five years. Upon receipt of the news of his death, the entomological seminar of Cornell University, then in session, passed the following resolutions of respect:

The members of Jugatae, Entomological Club of Cornell University, have received with deep sorrow news of the passing of the distinguished entomologist, Dr. A. D. MacGillivray. His wonderful career was begun among us. The foundation of his great service to science was laid in the laboratories in which his tradition still survives.

No one has done more careful and painstaking work as an investigator than he. Few men have had a larger share in teaching entomology to the youth of America. His leadership was elevated. His zeal for the truth was unbounded. His insight was keen. His criticism was very kindly. He was helpful and generous always.

He was a founder and for many years a member of our club. He was our colleague and friend; and at the sudden termination of his brilliant career, we pause to pay to his memory our fitting tribute of affectionate regard.

DR. FRANK HAGAR BIGELOW, until recently director of the Solar and Magnetic Observatory at Pilar, Argentina, and from 1891 to 1910 professor of meteorology in the U. S. Weather Bureau, has died in Vienna, at the age of seventy-three years.

CHARLES MEREDITH BURK, M.D., assistant instructor and instructor of zoology (vertebrate anatomy) in the University of Pennsylvania from 1888 to 1899, died at his home at Elkins Park, Pa., on December 28, in his fifty-fifth year. He was the author of "The Myology of the Pigeon (*Colomba livia*), a Study of the Muscular System of the Pigeon (Phila., 1893, 67 pp., 3 pls., 12vo., published privately). For the last twenty-five years he had successfully devoted himself to general medical practice in Philadelphia.

CAPTAIN THOMAS HENRY TIZARD, F.R.S., known for his work in hydrography under the British Navy, died on February 17, in his eighty-fifth year.

SIR MALCOLM MORRIS, the distinguished British physician, well known for his work in public health, died on February 19, at the age of seventy-four years.

DR. L. PERINGUEY, director of the South African Museum at Capetown, died on February 20.

THE twelfth annual meeting of the Eugenics Research Association will be held at Cold Spring Harbor on Saturday, June 14.

AT the Brooklyn Botanic Garden the following public lectures are announced for April and May to be given on Sundays at 3:30 p. m.:

April 13. *Scenic wonders of the northwest:* LEROY JEFFERS.

April 27. *The trees of greater New York:* DR. ARTHUR HARMOUNT GRAVES, curator of the Brooklyn Botanic Garden.

May 4. *Tropical plants in our daily lives:* DR. ORLAND E. WHITE, curator of the Brooklyn Botanic Garden.

The following lectures, part of a series to be continued in the fall, will be supplemented by a short trip in the Botanic Garden, conducted by the lecturer, for the purpose of seeing at first hand the plants discussed:

May 18. *Rock gardens:* MONTAGUE FREE, horticulturist, Brooklyn Botanic Garden.

May 25. *Irises:* DR. GEORGE M. REED, curator, Brooklyn Botanic Garden.

COPIES of electrical engineering standards issued during 1923 by European standardizing bodies have been received by the American Engineering Standards Committee and can be furnished at a nominal charge, or the copies on file may be consulted at the office of that body.

IN response to the recommendation of the Section on Anthropology at the Australian meeting of the Pan-Pacific Congress, the Bishop Museum has begun ethnological investigations in Micronesia under the direction of Hans G. Hornbostel. During the present year provision has been made also for field work in Manua and Tutuila.

THE Academy of Natural Sciences of Philadelphia, at its meeting of March 18, 1924, adopted amendments to the By-Laws creating an honorary class of members known as "fellows," to be chosen from the regular membership list of the society in recognition of their scientific attainments. The election of "fellows" is placed in the hands of the council of the academy. At each regular December meeting the council will receive the nominations which have been made in accordance with provisions of the amendments adopted. After proper consideration of the qualifications of the candidates the council, by a three fourths affirmative vote, may elect such candidates as in its opinion meet the standards to be set for "fellows" of the academy.

THE number of births in the large cities of Germany was very small last year. According to the *Journal* of the American Medical Association, during the first quarter, January–March, it was only 16 per thousand inhabitants, on a yearly basis. If we divide the cities into seven groups, we find that Berlin, with 3,990,000 inhabitants, had the smallest number of living births (exclusive of transient residents), namely, only 10.7. The second lowest number was in the industrial region on the Rhine and the Main, including Frankfort, Mannheim, Mainz, Wiesbaden and Ludwigshafen, the registration being 14.2. The third lowest number was recorded in the Saxon industrial section, including Dresden, Leipzig, Chemnitz and Plauen (15.3). The five south German cities, Munich, Nuremberg, Stuttgart, Augsburg and Karlsruhe follow (15.4). The seven large seaport towns rise above the average for the empire (16.4). The seven north German cities Breslau, Hanover, Magdeburg, Halle, Kassel, Brunswick and Erfurt made a very good showing (17.2), but the best record was reported from the Rhine-Westphalian industrial center (21.5). In Berlin the birth rate (10.7) had fallen so low that it is far exceeded by the mortality rate (14.7).

A NOTE in *Nature* states that the Botanical Society of South Africa was founded in 1914, when with a membership of 352 it commenced its task, not merely of developing a general interest in botany in South Africa, but also of assisting the establishment and development of a National Botanic Garden at Kirstenbosch. The value of the society to the work of the garden has been repeatedly acknowledged both by the former honorary director, the late Professor Pearson, and the present honorary director, Professor R. H. Compton. More than £3,000 has been handed over to the garden from the society's income, while special grants to specific pieces of developmental work have brought into being the rockery in the Dell, the pond in the Great Lawn, and a part of the Aloe Kopje. At the same time, still more valuable work has been done in interesting South Africans in the great scheme of which the shell as yet alone exists at Kirstenbosch, and many of the devoted collectors now supplying plants from all parts of South Africa for the garden were first brought into touch with the garden through the society. Its membership steadily increases and approaches its first thousand. The report for 1922 of the honorary director to the trustees of the garden has just been issued, and shows unmistakably the need there is for the efforts of such a society, which may with growing authority press more firmly the claims of these gardens upon the state. It is said that the lack of capital prevents essential developments in the proper housing of a trained personnel, without which the real development of these gardens, an essential requirement for South Africa's future prosperity, can not possibly take place.

THE Rothamsted Experimental Station, as announced in the London *Times,* is one of the institutions to which the Empire Cotton Growing Corporation has made a grant of £1,000 for five years, for research work likely to be of importance in relation to problems connected with cotton growing. The money will be employed in increasing the staff and equipment of the soil physics department in order that more rapid progress may be made in the study of the fundamental physical properties of soil. Special attention will be devoted to the water relationships in view of their importance in districts where cotton is grown. It is stated that the elucidation of these principles is necessary before reliable advice can be given to the growers, and conversely, that the practical problems local experts are expected to solve often present points requiring investigations in a research laboratory under controlled conditions. The soil physics department at Rothamsted will undertake these investigations as part of its study of the fundamental properties of soil. The department will act as the headquarters of those men on study-leave who wish to

discuss soil problems arising in their work, and they will be provided with facilities for experimental investigations.

PRESIDENT HENRY F. OSBORN, of the American Museum of Natural History has received the following telegram from the well-known geologist of southern California, Robert T. Hill: "Human remains found here completely fossilized. Occur twenty-five feet deep in horizontal stratified material of old recent or latest Pleistocene. No possibility of intrusion or confusion with outwash or Santa Barbara occurrence. Considered most unquestionable ancient occurrence yet reported. Material well cared for by Bryan and Stock." The scientific experts mentioned are William Alanson Bryan, director of the Los Angeles Museum, and Chester Stock, of the University of California.

UNIVERSITY AND EDUCATIONAL NOTES

THE University of Colorado has received a grant of $180,000 from the General Education Board and a gift of $120,000 from Mrs. Verner Z. Reed, of Denver, Colorado, to provide equipment for the new medical school and hospital plant now being erected in Denver. This consists of a large central building to house the medical school and general hospital, a psychopathic hospital, a nurses home and training school, and a power and heating plant. In addition to the gifts mentioned above, the funds for the new institution have been contributed as follows: the General Education Board has given $700,000; the Carnegie Corporation, $100,000; the State of Colorado, $950,000, and private individuals, $160,000. The school will be opened in September.

AN anonymous legacy of $200,000 for the establishment of an endowment fund for research work in the department of pediatrics has been received by Cornell University Medical School.

BY the will of the late Dr. Emmett Holt, Columbia University receives the sum of $25,000 for the establishment of a fellowship for the study of diseases of children. The Babies' Hospital of New York City also receives $25,000 to be used for the support of research work in the wards and laboratories of said hospital.

IN honor of Dr. Charles William Eliot a loan fund of $2,000 has been established at the Harvard Medical School by an anonymous friend of the university. It will be used to assist needy students in the medical school, under provisions to be determined by the dean, and will be known as the Charles William Eliot Loan Fund. The original donor specified that the fund might be increased from time to time with the thought that other individuals interested both in the medical school and in such a tribute to Dr. Eliot might wish to add to the established fund.

DR. FREDERICK L. RANSOME, who has been in charge of the section of metalliferous deposits with the United States Geological Survey since 1912, and who has during the present college year held the position of professor of economic geology in the University of Arizona at Tucson while on leave of absence from the survey, has accepted permanently the chair of economic geology at the University of Arizona, and will resign from the survey.

DISCUSSION AND CORRESPONDENCE

PORTRAITS OF NATURALISTS AT STANFORD UNIVERSITY

BEGINNING in the year of the great earthquake in California, 1906, there has gradually come into existence, at Stanford University, a collection of portraits of eminent naturalists which deserves more than local recognition.

These are not, as a rule, photographs, for the strong light of this climate has made me doubt the wisdom of collecting portraits done in a medium the permanence of which, in certain instances at least, is questionable. A serious attempt has been made, therefore, to collect engravings and prints of other sorts with a view to greater permanence.

These portraits are framed and hung on the walls of the library of the department of botany. As one enters this room from the hall one faces the impressive figure of Charles Darwin, two thirds life size, an India proof of the etching by Flameng from the painted portrait of Collier in the National Portrait Gallery in London, the portrait made familiar by photogravures which were reasonably numerous twenty-five or more years ago, but in the finer form of etching increasingly rare.

To the right, one sees an artist proof, by the same painter and etcher, of Huxley, also increasingly rare. The beautiful portrait of Charles Darwin, which bears his signature (whether in facsimile or original, I have not been able to determine) is flanked by portraits of his father and grandfather on one side and his son, Sir Francis Darwin, on the other—four generations of this famous family being revealed to the visitor and student. Comparison of these four faces leads to interesting impressions—comparison of the four figures, assuming the equal fidelity of the four portraits—leads to the conclusion that overeating is less common than formerly! On the same wall is a lithograph portrait of Henslow—for "Darwin walked with Henslow."

A steel engraving of Sir Joseph Hooker, seated in a Himalayan landscape and waited upon by natives bringing collections of rhododendrons and other

plants associated with his name, is another of the portraits in this collection. Lithographs of Sir Joseph and his father Sir William Hooker are also here.

A mezzotint engraving of Humboldt, seated in his ornamental shirtsleeves under a banana palm, with what might be mistaken to be an iceberg in the offing, is another composition which leads one to question the value of the picture as portraiture, though there can be no question of its value as a print. A beautiful engraved portrait of Linnaeus, dated 1779, is one of the treasures of the collection.

It is not necessary to list these pictures, but one word may be said as to how they have been accumulated. In the catalogues of second-hand book dealers one finds lists of portraits, some of which are undesirable because of inferior workmanship or for other reasons. In these lists one occasionally finds fine things, and some of our best pictures have been secured from second-hand book dealers. On the other hand, the interest of friends or of institutions has resulted in our getting other portraits not obtainable by purchase. Thus, we have an artist proof wood-engraving of Asa Gray, by Kruel, the gift of the Gray Herbarium. We have a very fine photograph of W. T. Sedgwick and an engraved portrait of Harvey which Sedgwick himself bought at Oxford, both of which were given to us by his widow.

Attention is called to this collection now because of our conviction that the presentation of face and features of the men who make science gives to it a human quality which those who are beginning to devote themselves to it ought not to miss; and in the second place, to invite additional contributions to a collection the value of which is already established. I should be very glad to receive correspondence relative to portraits of other eminent naturalists and to welcome gifts should any follow.

GEORGE J. PEIRCE
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SCIENTIFIC PUBLICATIONS FOR EUROPEAN LIBRARIES

THE American Library Association, through one of its committees, is endeavoring to supply to European libraries, unable under present conditions to purchase in America, some of the American books and periodicals which are so sorely needed.

Files of SCIENCE, covering the years since 1914, are in great demand and our committee can use to the very best advantage at least twenty sets. If any of your subscribers who have files that they are willing to contribute for this purpose will send them to me, they will be doing a great service, not only to their European colleagues, but to the interests of science in general.

Files of almost any other scientific journal are also welcome.

The committee will be glad to pay express charges on anything that is sent to them.

Parcels should be addressed, *Princeton University Library (Books for Europe) Princeton, N. J.*

JAMES THAYER GEROULD,
For the Committee

GRANTS FROM THE RUMFORD COMMITTEE

As chairman of the Rumford Committee of the American Academy of Arts and Sciences I wish to direct attention to the decision of the committee by which the term "light" is considered to include the spectral region of the x-rays.

Under this interpretation the field in which grants may be made from the funds at the disposal of the committee is extended to include researches in x-rays.

THEODORE LYMAN
JEFFERSON PHYSICAL LABORATORY,
CAMBRIDGE, MASS.

SCIENTIFIC BOOKS

Botany: Principles and Problems. By EDMUND W. SINNOTT. Pp. xix + 385. Figs. 240. McGraw-Hill Book Company, Inc., New York, 1923.

TEXT-BOOKS in science fall naturally into two classes as to authorship—those whose authors are primarily interested in the science, and those whose authors are also interested in the teaching of the subject and in its use as an educational discipline. Sinnott's new text falls into the latter class. Authoritative and clearly presented from the standpoint of modern botany, it is very obviously a product of successful classroom and laboratory experience with college classes.

The book "endeavors to set forth somewhat briefly and concisely the more important facts concerning the morphology, physiology and classification of plants, and to provide a body of problem material which may be of assistance in stimulating thought and in promoting class discussion." Teachers, especially young teachers and those of more experience but burdened with a heavy schedule of classes, will welcome the "Questions for thought and discussion" and the "Reference problems" given at the end of each chapter. Students will also benefit thereby. Some one has well said that education in any given subject does not consist so much in information as in learning how to think in that subject. The organization of Professor Sinnott's text is well calculated to accomplish both results.

Of seventeen chapters, the first two are introductory in nature, the third deals with the soil and its importance to plants, and the next three with the root

and its functions, the leaf and its functions and the stem and its functions, respectively. In the chapter on the leaf, and in several diagrams, photosynthesis is presented in a way that might give the impression that it is the function of leaves and of no other part of a plant. Thus, on page 20, under "Metabolic processes," photosynthesis is not mentioned in the list of physiological activities that "are not confined to any one organ," although, as the author of course well knows, taking spermatophytes as a whole, photosynthesis may be the function of roots, stem, leaf, perianth or any other green organ. For this reason some botanists think it preferable to treat of photosynthesis (and other activities) as a process which may go on in any organ, or even in plants without "organs" (*e.g.*, *Pleurococcus*)—a function, in fact, not of an organ but of a tissue, chlorenchyma.

Chapters VII (metabolism) and VIII (growth) are followed by an ecological chapter, "The plant and its environment." Here the more usual definition is given of the various tropisms as movements. Phototropism, for example, is defined as "any movement which is a specific reaction to the stimulus of light"; geotropism as "any reaction to the stimulus of gravity." To the reviewer it is preferable to regard the tropisms, not as movements or reactions, but as properties of the plant or organ by which it can detect any unilateral stimulus. It may or it may not respond, by a motion, depending on whether one kind of stimulus (*e.g.*, light) is overpowered, so to speak, by another kind of stimulus (*e.g.*, gravity), or whether response is mechanically hindered. The bending of a stem in the direction of the brightest illumination is a *reaction*, not a tropism. The author, however, is in good company in defining these terms as he does, and this comment is not for the purpose of pointing out an inaccuracy or error but is only propaganda for another and preferable (?) definition of terms.

Chapter X, on reproduction, is followed by one chapter on heredity and variation and one on evolution. Heredity is defined (p. 206) as the "tendency for offspring to display the particular characteristics which distinguish their parents." Here, again, the author is in fairly good company, but some students of heredity regard this definition as more or less misleading, if not, indeed, incorrect. The author's figure 128, in the same chapter, shows types of four successive generations of ferns as illustrated by leaf character. The "tendency" here is evidently toward unlikeness, instead of likeness, and yet all that the generation represented by each leaf had to start with was *inherited* from the parent from which it so widely differs. Is it not preferable to define heredity as all that an individual receives from its parents (*i.e.*, all it has to start with—the organization of the fertilized egg)? The *expression* may or may not resemble the parent; there may even be no *tendency* at all to resemble the parent, but quite the contrary.

Chapter XIII, on the plant kingdom, is followed by the last four chapters on the thallophyta, the bryophyta, the pteridophyta and the spermatophyta, respectively. The term Pteridophytes is used in its older signification as including horsetails and club mosses as well as true ferns, but this, probably, will not disturb the majority of botanists.

The illustrations illustrate (which is not the case in some texts), the typography and general make-up of the book are attractive, and the book should appeal to beginning students. Teachers are sure to welcome it as a valuable addition to botanical texts and a real contribution to botanical pedagogy.

C. Stuart Gager

Brooklyn Botanic Garden

LABORATORY APPARATUS AND METHODS

A NEW PHOTOELECTRIC CELL

In continuation of a previous investigation described at the meeting of the American Physical Society in Chicago in November, 1922, an abstract of which appeared in the *Physical Review*, 21, p. 210, 1923, the influence of very thin films of alkali metals has been studied. It has been found possible to control the flow of photoelectrons and of thermions by actuating invisibly thin films of alkali metals by light.

Remarkable photoelectric phenomena have been observed with a two-electrode photoelectric cell consisting of a glass tube supplied with a bulb at each end. Each bulb has inside a hemispherical deposit of metallic potassium and a platinum electrode connected with the sensitive layer. Care was taken that the connecting tube itself separating the bulbs had no visible deposit on its wall. When the bulb with its electrode connected to the negative side of a battery is illuminated, it shows the usual photoelectric effect; if, however, the transparent connecting tube is also illuminated, the deflection of the galvanometer inserted in the circuit increases considerably. The illumination of the positively charged anode has no perceptible influence in either of the mentioned cases. If the positively charged potassium layer had the property of reflecting the electrons as observed by Langmuir (Science, November 16, 1923) for caesium on nickel electrodes, a decrease of the photoelectric current should be expected when the anode is illuminated. No such action of the positively charged potassium layer was observed.

The relation between the photoelectric current passing the transparent connecting tube and the potential applied was observed for the case, when only the cathode was illuminated and also when both the

cathode as well as the connecting tube were illuminated. Table 1 gives values observed with a cell, the controlling tube of which was about 8 cm long and 2 cm in diameter.

TABLE 1

V	I_d	I_i	ΔI	I_i/I_d
20	1.75	44.75	43.	25.6
30	3.25	55.5	52.25	17.1
40	6.50	71.25	64.75	11.
50	16.50	94.	77.50	5.7
60	31.25	121.	89.75	3.84
80	82.50	180.	97.50	2.18
120	212.	330.	118.	1.55
160	420.	474.	54.	1.13
200	514.	532.	18.	1.04
240	555.	568.	13.	1.02
280	570.	585.	15.	1.02
320	580.	593.	13.	1.02

The first column indicates the potential difference in volts, under the action of which photoelectrons are driven from the cathode bulb, through the transparent glass tube to the anode bulb. The second column gives in arbitrary units the current I_d flowing through the tube, when only the cathode bulb alone is illuminated. The third column gives the current I through the tube, when in addition to the cathode bulb the adjacent tube is also subjected to light, causing an increased current I_i. The increase $\Delta I = I_i - I_d$ due to illumination of the tube is shown in the fourth column. The fifth column gives the ratio I_i/I_d showing a rapid decrease with increased voltage. So, for instance, for 20 volts the current increases about 25 times when the tube is illuminated, but for 120 volts the increase is only 50 per cent. and for 200 volts only 4 per cent.

The values of I_d and I_i plotted show two saturation curves one above the other, the one with higher values of the current corresponding to the case when the connecting tube is illuminated. The increase of current due to the latter reaches a maximum for a voltage of 100 volts corresponding to the middle part of the saturation curve. The transparent tube is much more sensitive to variations of illumination than the sensitive layer in the cathode bulb. A shadow 1 millimeter wide cast from a wire across the cathode bulb does not affect the electron current, but the same shadow cast across the transparent tube causes a perceptible decrease of the galvanometer deflection. If the connecting tube is illuminated while the cathode bulb is in darkness, the current is nearly zero. It follows that the inner glass surface contributes very little to the total current. Its action consists in facilitating the passage of electrons from the cathode bulb into the anode bulb. The increase of current due to illumination increases with the length of the transparent tube subjected to light, showing a linear relation between the values of the illuminated area and the increase of current produced by the action of light.

The effect is selective, the increase depending on the wave length as well as on the intensity of the radiating source used for the illumination of the transparent glass tube.

The behavior of the transparent tube remains similar if as a source of electrons produced at the cathode thermions are used instead of photoelectrons. Table 2 gives values for a cell the cathode of which consists of an oxide coated filament 15 mm long heated with a current of 2 amperes.

TABLE 2

V	I_d	I_i	ΔI	I_i/I_d
370	.6	27.	26.4	45.
410	9.4	75.5	66.	7.55
450	55.5	133.	78.5	2.95
490	166.	266.	100.	1.6
535	475.	655.	180.	1.38
575	1182.	1515.	333.	1.28
615	4860.	5340.	480.	1.1

The tube connecting the two bulbs was treated with potassium vapor and then by heating the deposit was removed so that no visible trace of a film was left on the glass. Applying low differences of potential, very few thermions can pass the tube from the heated cathode bulb to the anode bulb. However, when the tube is illuminated the number of electrons reaching the anode increases considerably.

Whether the source of electrons passing the transparent tube is a photoelectric layer activated by light, or a filament activated by heat, in both cases the inner surface of the tube acts like a transparent grid controlling the flow of electrons by means of a radiating source. Several devices based on this principle have been investigated.

The investigation is continued and the influence of different photoelectric substances, of wave length, of the emission of electrons at the cathode, intensity of the controlling radiating source, and the optical properties of the transparent grid is studied.

J. TYKOCINSKI-TYKOCINER,
J. KUNZ
UNIVERSITY OF ILLINOIS

SPECIAL ARTICLES

THE BENEFICIAL EFFECT TO PLANT GROWTH OF THE TEMPORARY DEPLETION OF SOME OF THE ESSENTIAL ELEMENTS IN THE SOIL

THE fertility of a soil is reflected in a large measure by the amounts of essential salt elements present

in physiologically available form. Available elements in the soil are considered to be those which constitute part of the solutes in the soil solution, or those that may readily become so. Investigators in this field hold that these elements in the soil solution are reflected to a very large degree, if not wholly, in properly obtained aqueous soil extracts. Whether these essential elements in water soluble form are physiologically available or not is, however, a matter outside of the pale of chemical analysis, be it of soil or plant; it is a consideration determinable only by physiological experiments. But whatever may determine the physiological availability of any element, a certain minimum supply thereof is required for any unit yield of product. Whether there is a supply or not is a matter determinable by chemical analysis of the water extract of soils.

In the magnitude of supply of essential elements, or in the rate thereof, as determined by chemical analyses of the water extracts of soils, investigators have found certain important relations that throw light on the crop-producing power of soils. Among these are Hall, Brenchley and Underwood[1] who state that water extracts of soil from the Broadbalk plots varied in direct accordance with their fertilizer treatments and history of the plots. Burd[2] and Stewart,[3] working with California soils, found that the water extracts of soils yielding large crops are not only richer in essential nutrients than are soils yielding much smaller crops, but that the rate at which nutrients are replenished is greater in the more fertile soils than in those of markedly lower productive power. These investigations and those of others that could be cited are proof that so far as marked differences in crop-producing power of soils giving large or small yields are concerned, they are in no small measure accounted for by the relative supply (or rate thereof) of available nutrients in the soil.

But at times, and occurring during the most active part in the growing period of many agronomic plants, the rate of removal of the essential elements in the soil is greater than that of their replenishment. This results in a temporary depletion of some of the available elements. The question arises at this point: Is this temporary depletion of some of these essential salt elements in the soil by the growing plant beneficial or not? Is this depletion a condition that increases the crop-producing power of the soil *per se*?

It appeared to the writer that an answer (or suggestions on this matter) could be most easily obtained from the results of culture solution experiments. The method employed was to arrange experiments where one of the seven elements required by plants and supplied by the soil, namely, K, Ca, Mg, Fe, S, N and P, was lacking for various lengths of time and at different periods in the growth cycle of wheat. A large number of wheat seedlings (200 cultures of 5 plants each) were started in nutrient solutions containing all the essential elements, also an equal number of cultures were set into nutrient solutions lacking in one of each of the seven elements named. At intervals of a month, a number of the cultures grown in the complete nutrient solution were transferred to the several partially complete solutions and those of the latter to the former. Changes were made with different sets at four different periods of growth; stages of one, two, three and four months. Control cultures were those that grew in these different solutions but were not changed in the manner indicated above.

Without going into the discussion of all the results obtained, which will be fully reported in due time,[4] suffice it to say that the most striking results obtained were from those cultures that grew one month in the complete nutrient solutions and were then transferred to the culture solutions devoid of potassium, in which they completed their growth cycle. Six weeks after the transfer was made, these cultures were nearly twice as high as those grown in complete nutrient solutions. The stimulation during this time consisted of a marked increase in vegetative vigor, increase in total weight and in hastened maturity. Very little growth was made by any of the cultures started in the solutions devoid of potassium. It was only after the plants were in contact with solutions containing all the essential elements for their early growth phase that they made exceptionally good growth in this nutrient solution.

These results, unexpected from casual considerations, are, in the opinion of the writer, in accord with what actually happens in soils growing field crops (such as the common cereals), although the relationship is not apparent unless viewed in the light of results obtained in physiological experiments. Referring now to the work of Stewart, the element whose supply was most markedly depleted by the growing barley plants in the 13 soils studied was nitrogen (NO_3). The rate of depletion was much greater in the soils producing large crops than in those produc-

[1] Hall, A. D., Brenchley, W. E. and Underwood, L. M., "The soil solution and the mineral constituents of the soil." *Phil. Trans.*, 204: 179–200, 1914.

[2] Burd, J. S., "Water extraction of soils as criteria of their crop-producing power." *Jour. Agr. Res.*, 12: 297–309, 1918.

[3] Stewart, G. R., "Effect of season and crop growth in modifying the soil extract." *Jour. Agr. Res.*, 12: 311–368, 1918.

[4] The first paper on this subject is to appear in *Botanical Gazette.*

ing small crops. Furthermore, the rate of depletion was much larger in the soils having high concentrations of nitrates at the beginning of the growing period than it was in those soils where the concentration of this element was much lower. In order to understand the significance of the depletion of nitrate as bearing on the relationship above referred to, it is necessary to bear in mind certain results obtained by the writer on the growth of wheat in the simplest culture media that can be devised, namely, combinations of one-salt solutions.[5] In these culture solutions, the plants were in contact with only two elements at any time during the entire growing period, being changed from one solution to another at regular intervals in order to supply the plants with all required elements. These culture solutions experiments showed very clearly that the physiological availability of any ion is largely dependent upon a certain specific ion (or ions, depending on the plant) of opposite charge. The element of opposite charge that predominantly determines the availability of potassium for wheat is nitrate. These two elements must be present together so that either can be most efficiently used and absorbed from the solution. All other elements can be absent from the media without detriment to the availability of these two elements to the wheat plants.[6] With the physiological availability of nitrate or potassium largely dependent upon the supply of one or the other, it follows from these considerations that when nitrates are depleted in any media, water soluble potassium becomes relatively unavailable physiologically. Stewart found that the nitrate content of the 13 soils he investigated was brought to a very low level by barley plants six to eight weeks after planting and kept low for several weeks thereafter. The effect of this depletion of nitrate in soils was to render water soluble potassium relatively unavailable physiologically. This, in essence, then, simulated the experiments herein described with wheat grown in complete nutrient solutions for one month, and then transferred to a solution devoid of potassium.

Study of the results of Stewart in this light brought forth a striking correlation in the differences in the yields of produce and that of the graphs showing the physiologically available potassium for these various soils. These graphs were prepared from the data of the chemical analyses of the water extract of the soils as found at fortnightly intervals. They were constructed by taking for any interval in question the amount of potassium found, if it was less than that of nitrate, to indicate the point (for that interval) of the projected graph. But if nitrate was less than that of potassium, at any interval, then the point for the curve was determined by the amount of potassium that combined as the chemically equivalent quantity with the amount of nitrate found in the soil. As nitrates were found to be practically depleted in most soils 8 to 10 weeks after planting, it follows that this period of growth was usually sufficient to indicate the type of curve for the graph of any kind of soil. While the best curves for these graphs would be those obtained by mathematical treatment, to which the data lend themselves, nevertheless it was found that a fair approximation to these curves could be obtained by drawing a straight line through each graph in such a way as to have equal areas of the segments of each graph above and below the line. This line becomes the hypotenuse of a right angle triangle, of which one leg shows the amount of physiologically available potassium in the soil at different times as indicated on the other leg. The magnitude of yield of barley of the thirteen soils was found to correspond in direct relation to that of the enclosed acute angle indicating the slope of the hypotenuse; the steeper the slope the greater the yield. These relationships even held for small differences in duplicate plots. It is from these striking correlations that the conclusion is drawn that for barley and similarly responding plants the *crop-producing power of soils is determined in a very large measure by the rate and the state of the temporary depletion of some of the essential elements in physiologically available form from a high level by the growing plant,* the soil where this is greatest being generally the most highly productive one.

In no way do these considerations invalidate the doctrine that the difference in crop producing power of soils is in a large measure accounted for by the magnitude of supply of available salt elements they possess; the more productive soils having a larger supply than the less productive ones. But the magnitude of supply is one of the factors that determines the rate of depletion; the other (or others) is concerned in the physiology of the plant. While the removal of salt elements from the soil is a process

[5] A full report of these investigations is being prepared. Brief papers on this subject have appeared. See "On the physiological balance in nutrient solutions." *Amer. Jour. Bot.*, 9: 180–182, 1922. "Water culture experimentation." SCIENCE, 66: 421–422, 1922. "Further notes on growing wheat in one-salt solutions." *Soil Science*, 15: 69–73, 1923.

[6] From investigations now in progress, it appears that potassium and nitrate are not the physiologically paired ions for all plants, or perhaps even for markedly different processes in the same plant. Whether one pair of ions or another is "physiologically paired" or not, appears as a characteristic of groups of plants, rather than of species. Thus potassium and nitrogen (NO_3) are the physiologically paired ions for the common cereals, wheat, barley, oats, etc., but appear not to be in the case of potatoes or sugar beets.

that leads to infertility, *i.e.*, if the rate of removal exceeds that of replenishment, determined over a sufficiently long period of time to take account of the effect of different kinds of cropping and soil management, nevertheless, it also plays a very important beneficial rôle in crop production. It appears as a unique relationship of physiological requirement and soil adjustment.

It appears that these considerations briefly alluded to in this paper are some of the more important factors that bear on the much discussed problem of how to give interpretation in terms of crop production to the chemical analyses of soils. It introduces a new formula—the rate of the temporary depletion of some of the salt elements, as an expression of soil fertility. It is a formula that includes the factor of supply, or rate thereof, whose importance has been generally emphasized by soil investigators since the time of Liebig, and two new factors, that of physiological requirement and soil adjustment.

That the temporary depletion of certain available nutritive elements in the soil by plants—the very process that contains the essence of the conditions that makes for infertility and soil exhaustion—is also one of nature's most important agencies and conditions essential for large crop production, is the conclusion of this paper. The rhythmic cycle of changes in the soil to which plant processes have become adapted is characterized by seasonal accumulations and production of available plant foods. This is a condition necessary for the growth of plants, but as some of these elements become depleted, or nigh so, by plants at certain phases of their growth, the absence of these elements in turn becomes a condition decidedly beneficial to growth. It appears that the failure to recognize and evaluate the physiological significance of these changes, constituted one of the chief obstacles that beclouded an understanding of the relationship of the available nutrients in the soil to crop production.

In a paper to appear elsewhere, the writer will treat the data obtained by Stewart in the light of this formula and discuss its application in the interpretation of chemical analyses of soils in terms of crop-production.

W. F. GERICKE

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THE AMERICAN MATHEMATICAL SOCIETY

THE two hundred and thirty-fourth regular meeting of the American Mathematical Society was held at Columbia University, on Saturday, March 1, 1924. This meeting was preceded, on the evening of February 29, by the society's first Josiah Willard Gibbs Lecture, delivered by Professor M. E. Pupin in the Engineering Societies' Building, New York City, before a large and distinguished audience, including, besides members of the society, a number of physicists, chemists and engineers who were present by invitation. Professor Pupin's lecture, entitled "Co-ordination," dealt in part with certain aspects of Gibbs's work.

At the meeting of the society the attendance included 47 members. The secretary announced the election of five persons to membership.

It was decided to hold a colloquium at Cornell University in the summer of 1925. No summer meeting will be held in 1924.

The following papers were read:

The outer multiplication of integral forms: F. D. MURNAGHAN.

A modification of tensor analysis: G. Y. RAINICH.

On the electromagnetic field in general relativity theory: G. Y. RAINICH.

The remainder in Charlier's integral formulas: R. E. GILMAN.

An existence theorem: EINAR HILLE.

Proof of the instability of the motions of asteroids whose periods are one half that of Jupiter: E. W. BROWN.

Thick rectangular plates: C. A. GARABEDIAN.

Generalization of certain theorems of Bohl: F. H. MURRAY.

Functionals of closed plane curves, invariant under one-parameter groups of transformations of the plane, and generalizations: A. D. MICHAL.

An unusual type of expansion problem: M. H. STONE.

On the order of an analytic function at a singular point: M. H. STONE.

Theorems concerning the division of a plane by continua: J. R. KLINE.

Geometries of paths for which the equations of the paths admit a quadratic first integral: L. P. EISENHART.

On the complete independence of the postulates for betweenness: W. E. VAN DE WALLE.

Equivalent rational substitutions: J. F. RITT.

New proofs of two well known theorems on quadratic forms: J. F. RITT.

A characterization of a bounded continuum which forms the common boundary of two domains in the plane: R. L. MOORE.

On the relation of a bounded continuum to its complement in the plane: R. L. MOORE.

Note on Brouwer's fixed point theorem: J. W. ALEXANDER.

On the dependence of the curvature upon the electromagnetic field: G. Y. RAINICH.

R. G. D. RICHARDSON,
Secretary